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Finnish Joint Research Plan for GPM

Brazil, March 4-6, 2008

Heikki Pohjola / Vaisala, FMI
Jarkko Koskinen, Jarmo Koistinen and Jouni Pulliainen / FMI

US-Finnish cooperation

- **Proposal submitted to PMM-team for approval**
  - Concentrates especially on winter precipitation in high latitudes
  - Work to be completed at two test sites in Finland
  - Contains five Work Packages with special emphasis on
    - Ground validation
    - Validation of GPM algorithms for high latitudes
    - Research related to microphysics of precipitation
    - Research related to snow cover and hydrology

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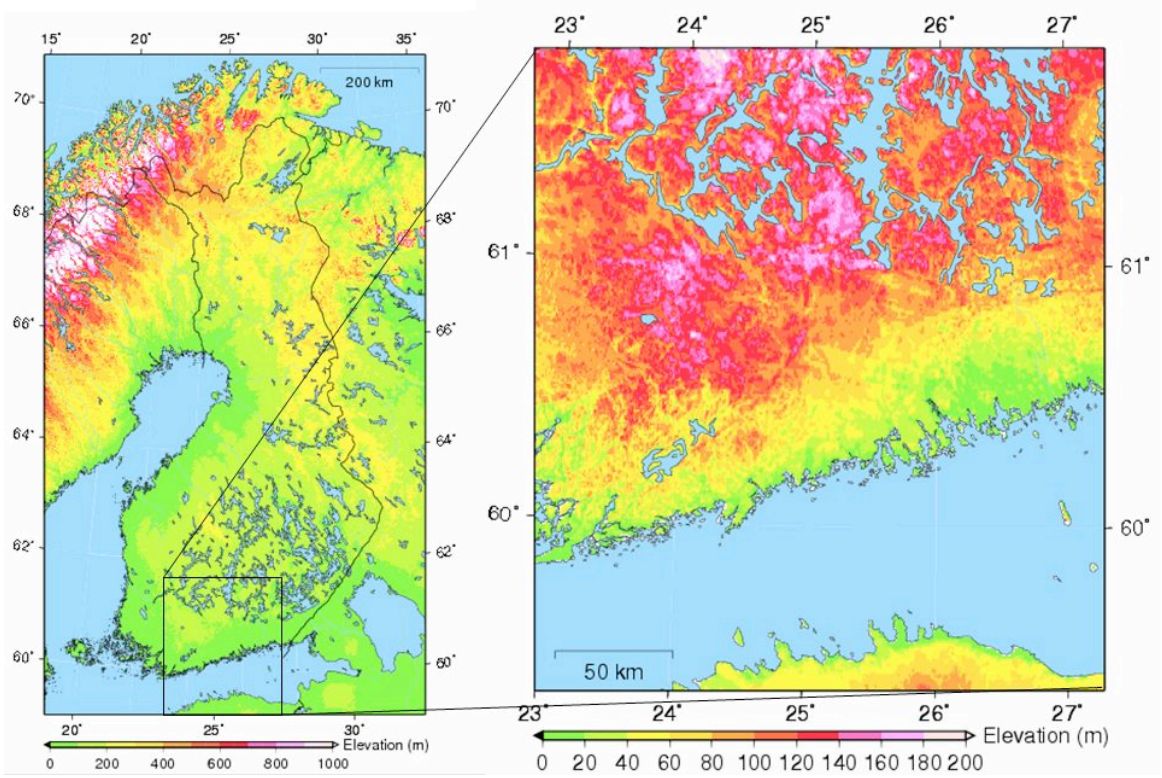
Helsinki Testbed

A high latitude mesoscale testbed

Finland has four seasons

- The annual snow cover settles during October to November
- The snow melt from March to May
- Mean maximum water equivalent from 100 to 200 mm



Helsinki Testbed research topics

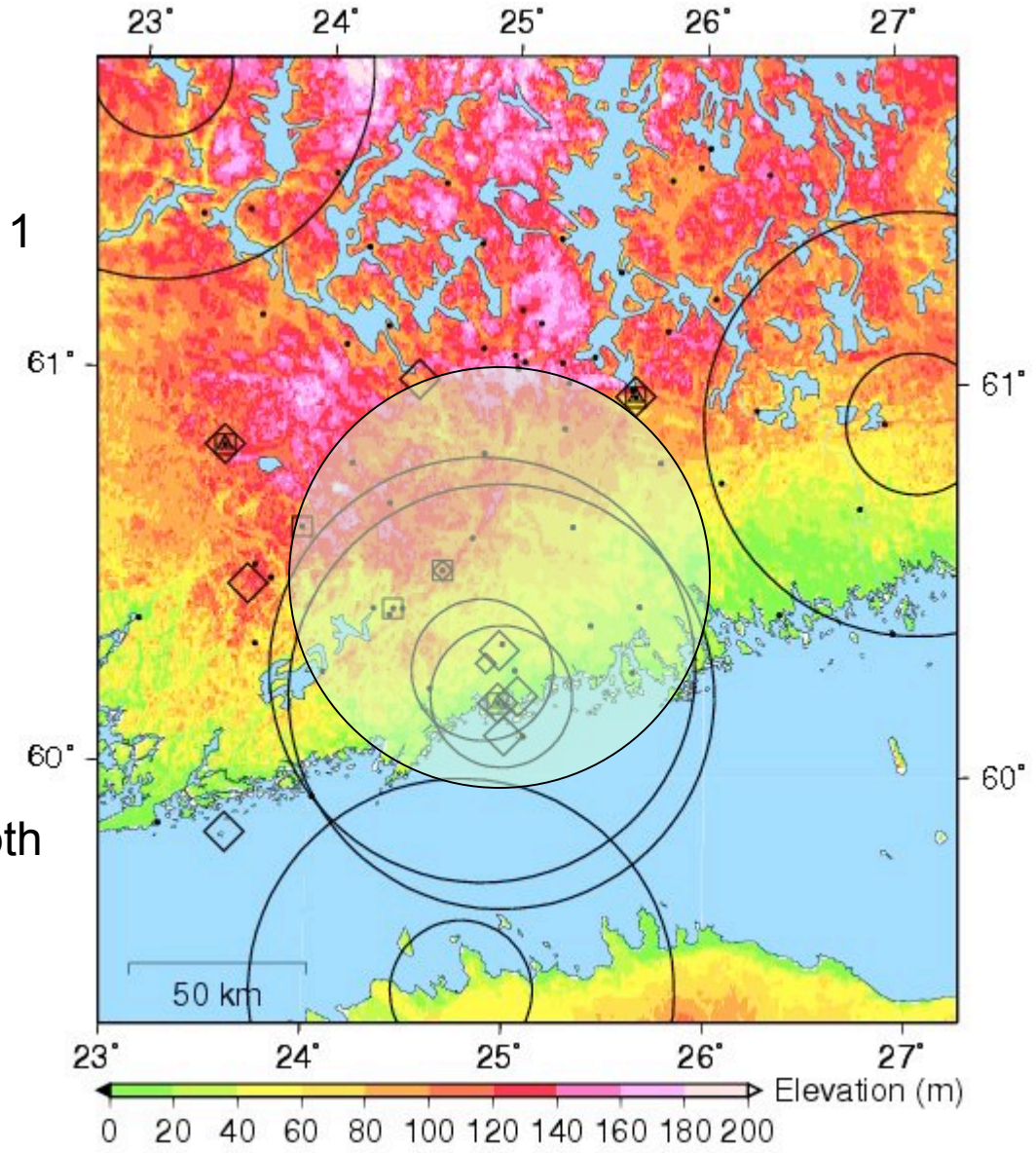
- Precipitation phase: rain/snow/mixed
- Visibility: fog, precipitation phase and intensity
- Inversion height and strength
- Air quality model
- Sea breeze
- Local area models
- Road surface radiation balance model

http://testbed.fmi.fi
Public real time data

YTV STUK NOKIA Finnish Road Enterprise TEKES VAISALA HELSINKI 2005 FINNISH ROAD ADMINISTRATION

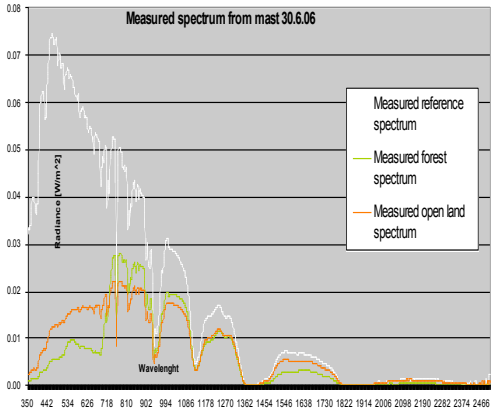
Precipitation measurements

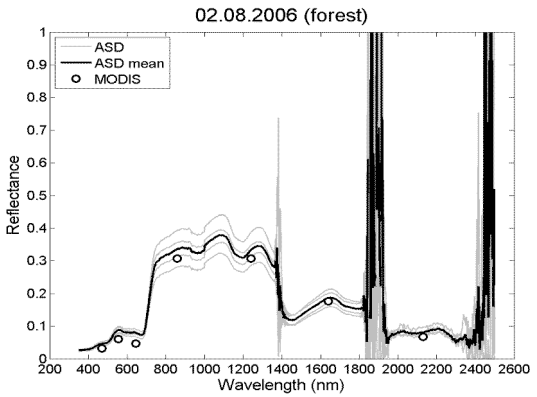
- Circles: 4 operational Doppler weather radars (FMI & EMHI), 1 Dual pol radar + 1 vertically pointing C-band radar for research (Vaisala & UH)
- 2 vertically pointing POSS-radars
- Dots: 80 gauges
- Big diamonds: FD12P optical scatterometers
- Triangles: ultrasonic snow depth
- Squares: weighing gauges



Sodankylä - Pallas

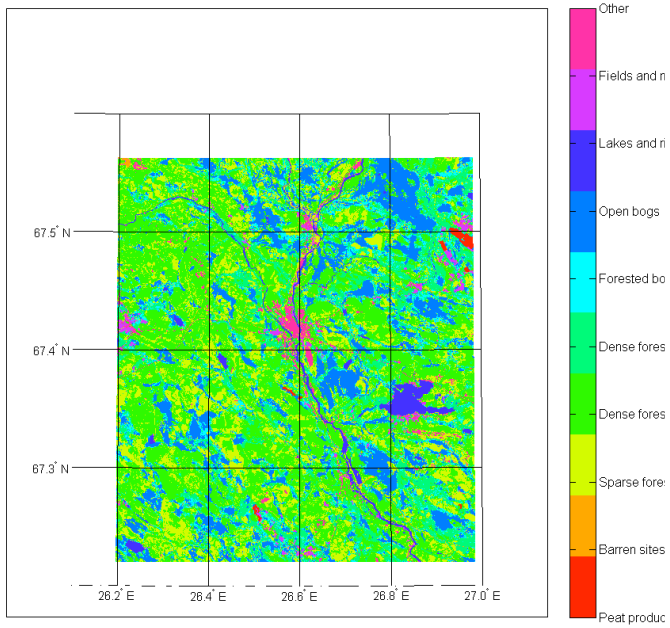
- CAL-VAL site for remote sensing satellites observing Earth's surface and atmosphere
- CEOP-site
- Ongoing activities related to different programs/satellites of NASA,ESA,EUMETSAT and co-operation with domestic/foreign research institutes





Reference ground truth data on surface and atmosphere from the Sodankylä-Pallas CAL-VAL site:

- **Time-series of observations such as:**
  - Aerosol information including aerosol optical depth (AOD) measurements
  - Atmosphreric profile and column observations on various parameters (eg. Ka band scatterometer)
  - Albedo and radiation observations
- **Time-series and/or campaign experiments on**
  - Soil-forest reflectance (ground-based and aerial data)
  - Microwave brightness temperature
- **Possibilities to include new instrumentation**



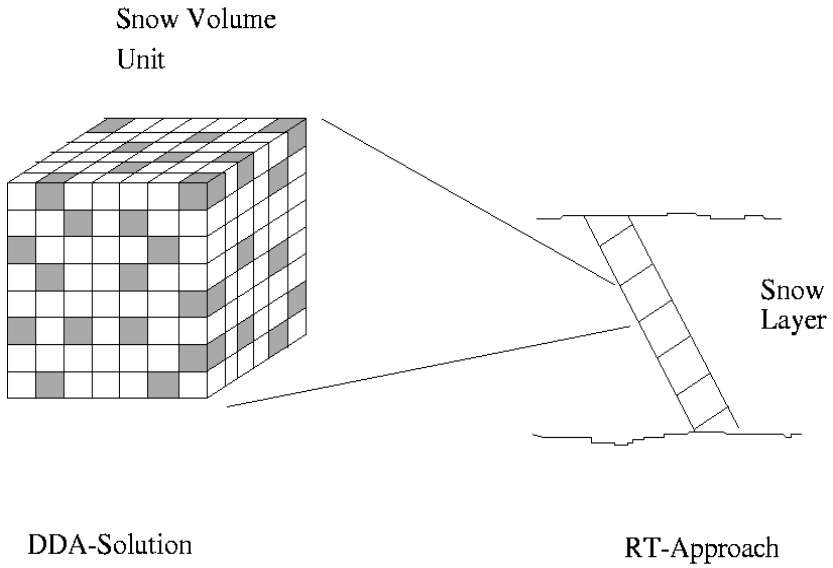
WP 1. Precipitation Process Studies

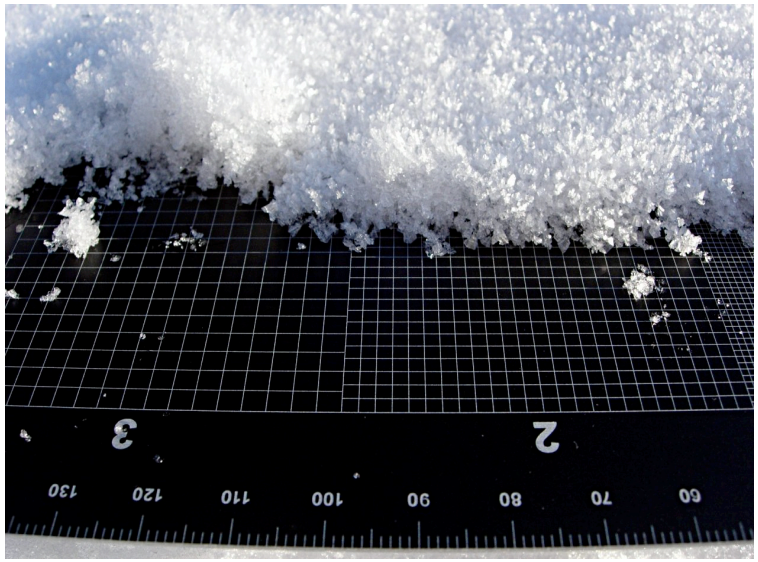
- **The purpose is physical process study and characterization of snow, mixed phase and liquid precipitation within the Helsinki Testbed (HTB)**
  - Research efforts will be coordinated with other PMM projects to provide relevant information to PMM/GPM precipitation retrieval algorithm developers.
  - These physical process studies will also be extended to quantitative precipitation estimation algorithms
  - US-Finnish *in situ* measurement campaigns

DDA-simulation of polarimetric scattering

Modeling of microphysics of precipitation

- Modeling of polarimetric quantities applying a general scattering model for remote sensing applications (DDA)
- So far the DDA-model has been applied in microwave scattering from snow cover and from the boreal forest
- Comparison to real measurements => algorithms for diagnostics



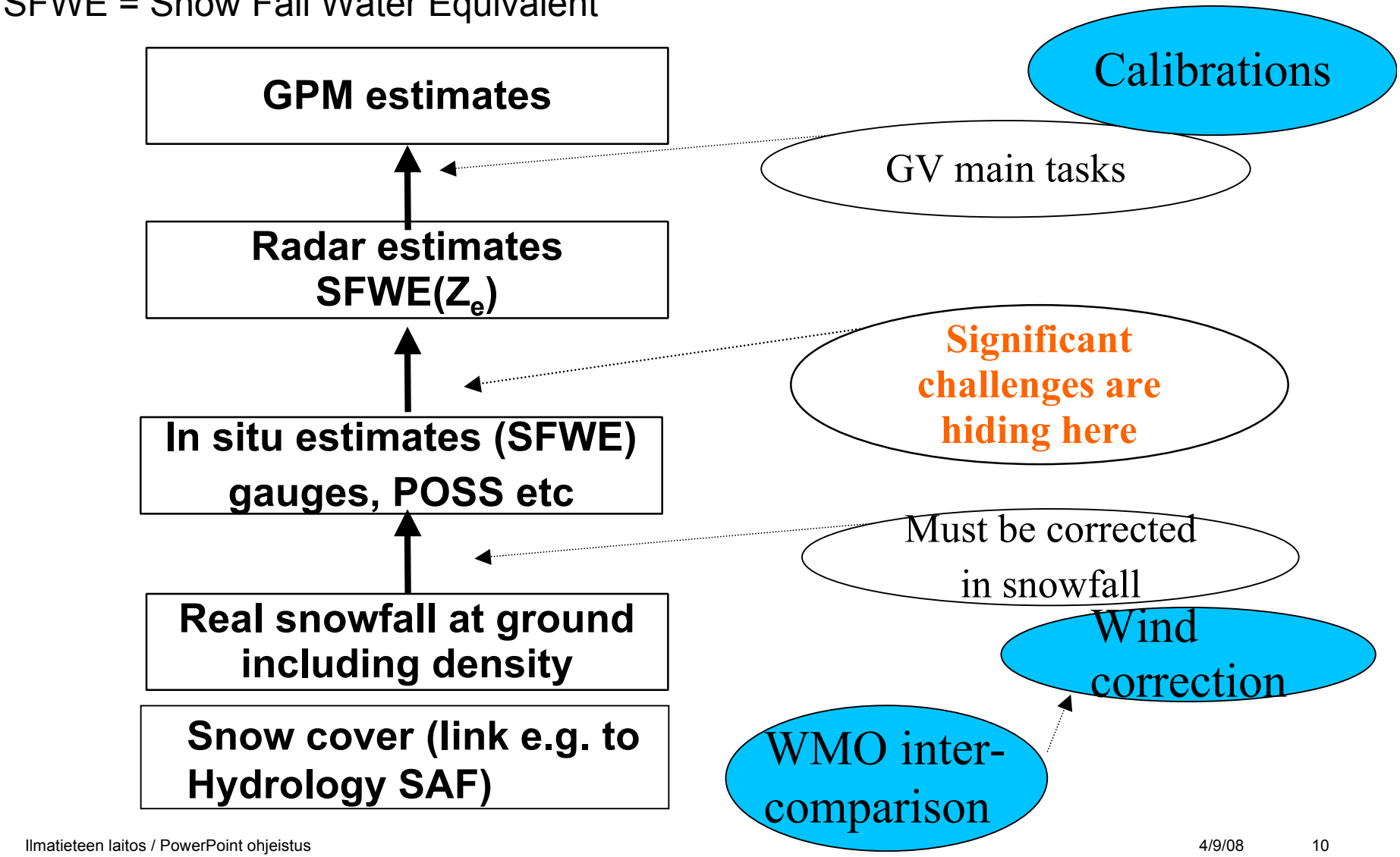


WP2. Falling Snow Algorithm Development for GPM

- **Specific purpose of this work:**
  - To investigate the vertical structures of falling snow events through the use of VPR´s and dual polarization variables measured by weather radar,
  - to perform a joint statistical analysis between reflectivity profile characteristics and AMSU-B, CLOUDSAT satellite brightness temperatures,
  - and to collect a database of coincident (or ensemble of coincident) datasets containing VPR´s, surface and atmospheric observations, and AMSU-B observations.

Ground reference process of GPM snowfall measurements

SFWE = Snow Fall Water Equivalent



WP3. GPM Hydrology Studies

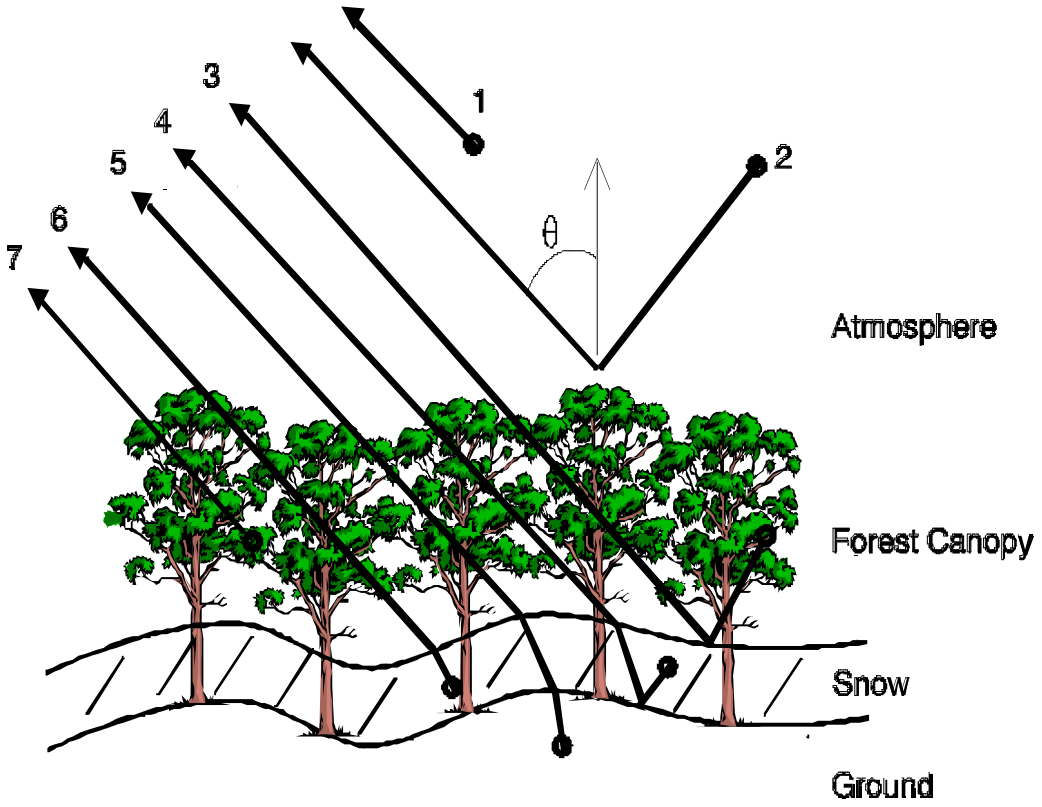
- **Specific purposes of this work:**
  - **To investigate the land surface emissivity/brightness temperature and radiance/reflectance** at frequencies to be sampled by GPM,
  - **the development and analysis of a joint database to investigate various downscaling approaches** for hydrological application of GPM products
  - **Test of satellite precipitation product in the operational forecasting** system WSFS at Finland

WP4. Snow emission and backscattering modeling

- **The purpose of this work**
  - Improve the retrieval of snow depth and snow water equivalent (SWE), using satellite instruments such as AMSR-E,
- **The physical components to be incorporated into the snow algorithms (emission models) include**
  - forest canopy on emission of the underlying snowpack,
  - varying snow crystal size on emission and scattering
  - the evolution of the snowpack through the course of the snow season.

HUT snow emission model

- Background
  - Semi-empirical model simple enough to be used for parameter retrieval from space-borne or airborne data
- Basic characteristics
  - Scalar radiative transfer model for single snow layer
  - Semi-empirical formulas for snow permittivity and extinction coefficient
  - Empirical coefficient for radiation contribution scattered in snow layer
  - Incoherent approach used for medium boundary effects
  - Soil-snow reflectivity by empirical soil emission models
  - Empirical formulas for atmospheric and forest cover effect



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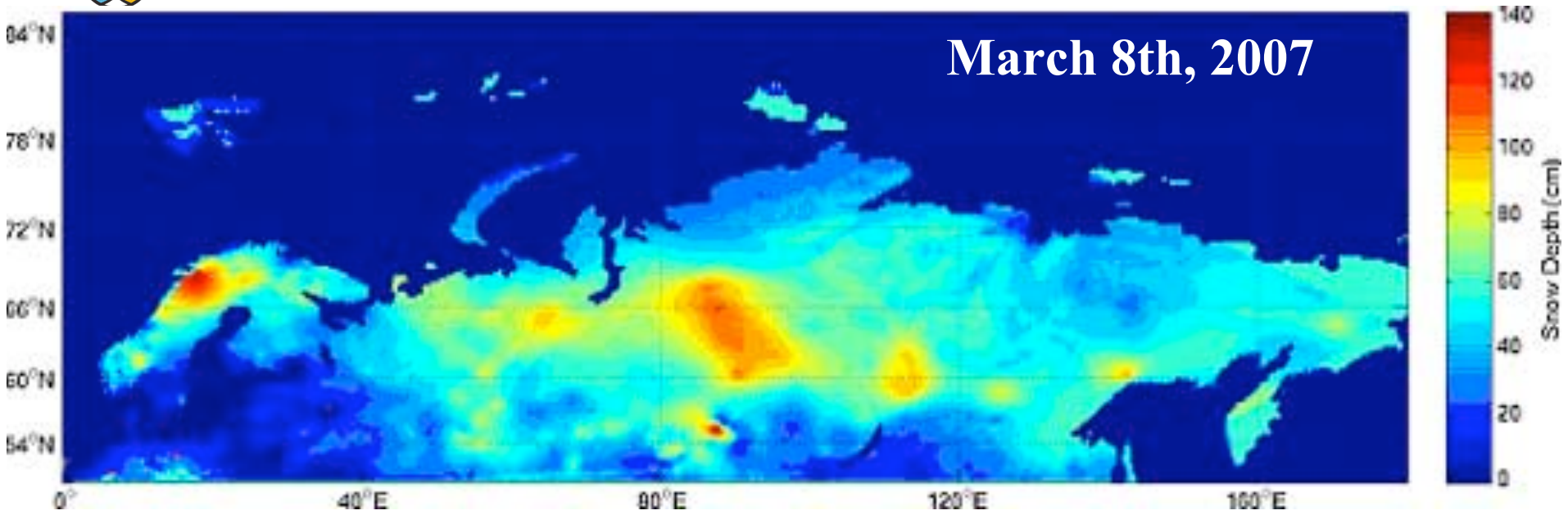
SWE map over Northern Eurasia



- The method is based on Bayesian data assimilation approach for the maximum value of the probability of SWE from time series of radiometer observations and *in situ* observations
- **Near real time maps available online: http://snow.fmi.fi**

WP5. Validation of Current and Future Satellite Precipitation Products at High Latitudes

- **Will utilize ground estimates of precipitation from the two Finnish test sites to compare with existing and developing satellite precipitation products during all seasons**
  - Helsinki Testbed (HTB) and
  - Sodankylä – Pallas
- **There are two major objectives:**
  - Compare daily merged satellite precipitation estimates to HTB In situ measurements
  - Develop ground based comparison products using radar and rain gauges to compare with daily and higher resolution precipitation products involving single and multiple satellites

Conclusions

- **Proposal submitted to PMM-team for approval**
- **Concentrates especially on winter precipitation in high latitudes**
- **Work to be completed at two test sites in Finland, Helsinki Testbed and Sodankylä Pallas**
- **Finnish Academy of Science founding application submitted**

Back up slides

Weather radar related research of snowfall

- **QC of radar measurements in snowfall and mixed rain and snow**
  - Rejection of non-meteorological measurement
  - Real time diagnosis of detection range in snowfall
  - Development of validation methods of QPE and common quality metrics for radar based snowfall measurements
- **QPE in snowfall and mixed rain and snow**
  - Does an optimal Snow Fall Water Equivalent (SFWE) – reflectivity factor and polarimetric quantity relation exist
  - Diagnosis of snow flake and crystal types including supercooled water (hydro class) and degree of melting from polarimetric radar
  - Study gauge-radar adjustment techniques in snowfall and diagnose sources of error in it.
  - Study attenuation, including polarimetric modelling of scattering, in partly melted precipitation (sleet) and find out practical equations to estimate it in operational measurements.
- **Vertical profile of reflectivity in snowfall and methods to correct the effects of it**
  - Statistical comparison of radar and satellite based VPRs at the same locations.
  - Diagnosis of evaporation and overhanging precipitation by radars, satellites and surface measurements and rejection of it from the ground level QPE

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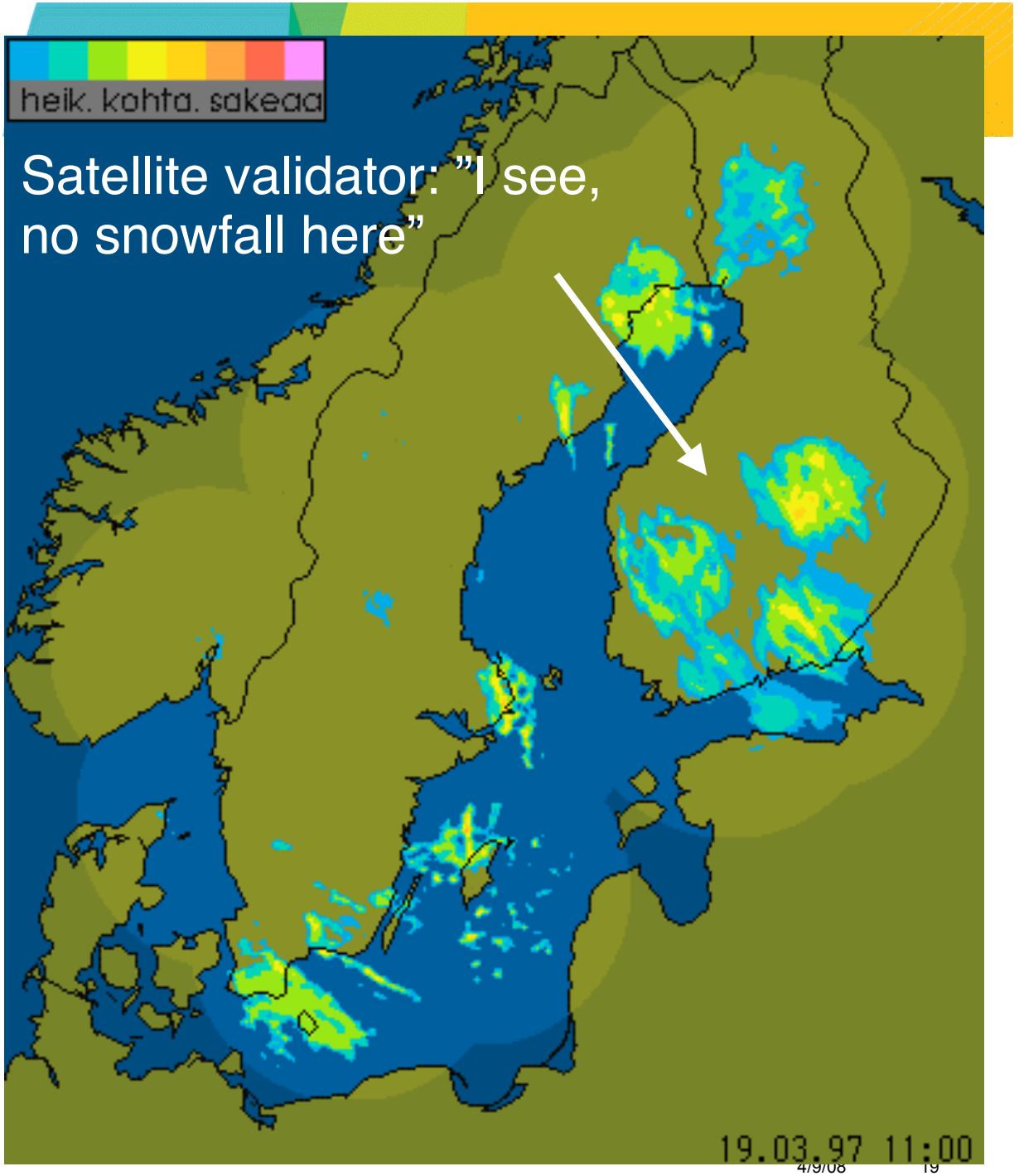
Beam overshooting

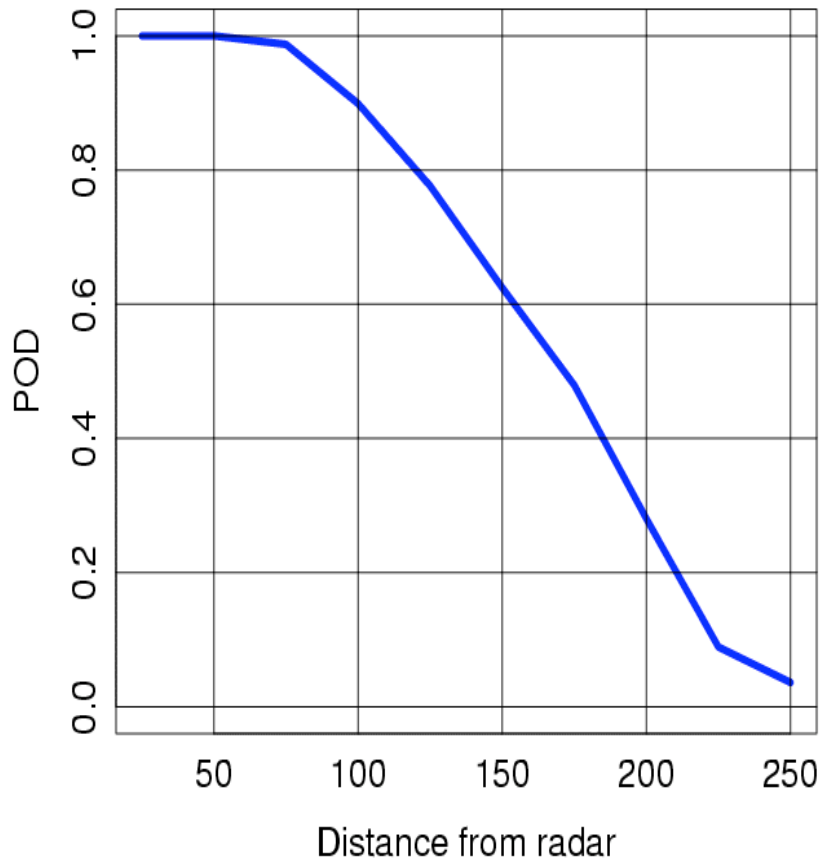
- Shallow snowfall often detected only at short ranges

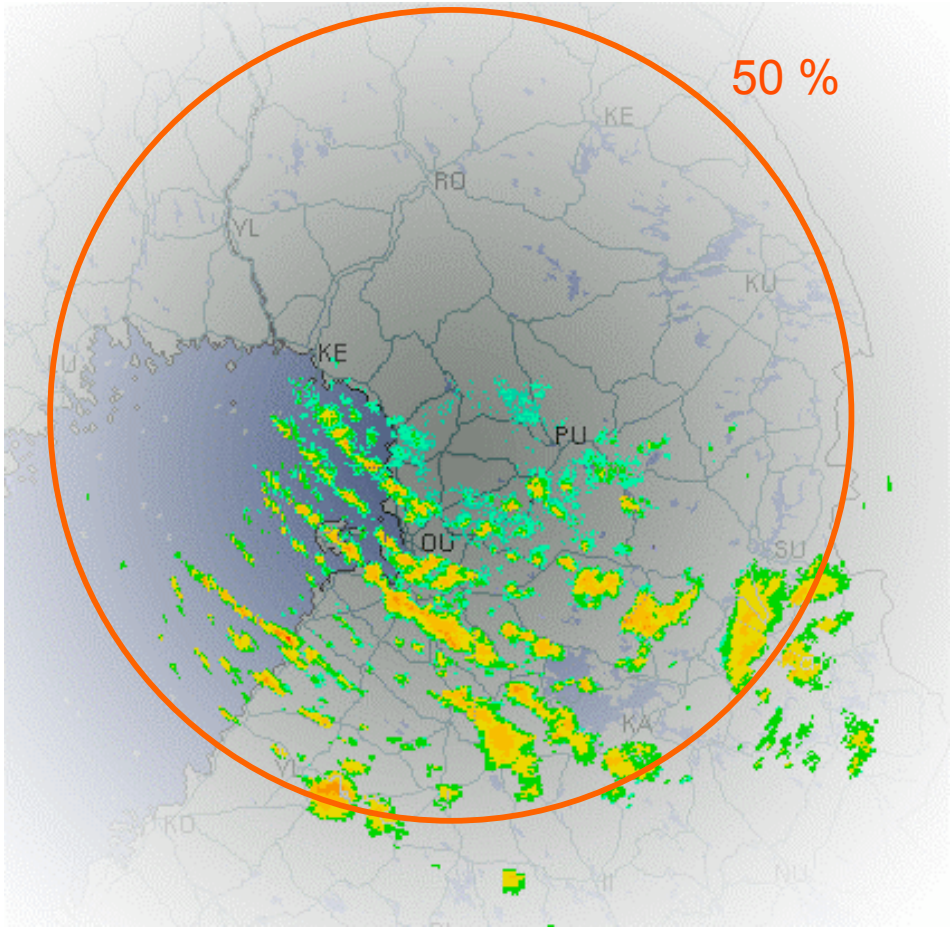
- Adding Probability of Detection (POD) of precipitation at echo free bins will enhance their quality.



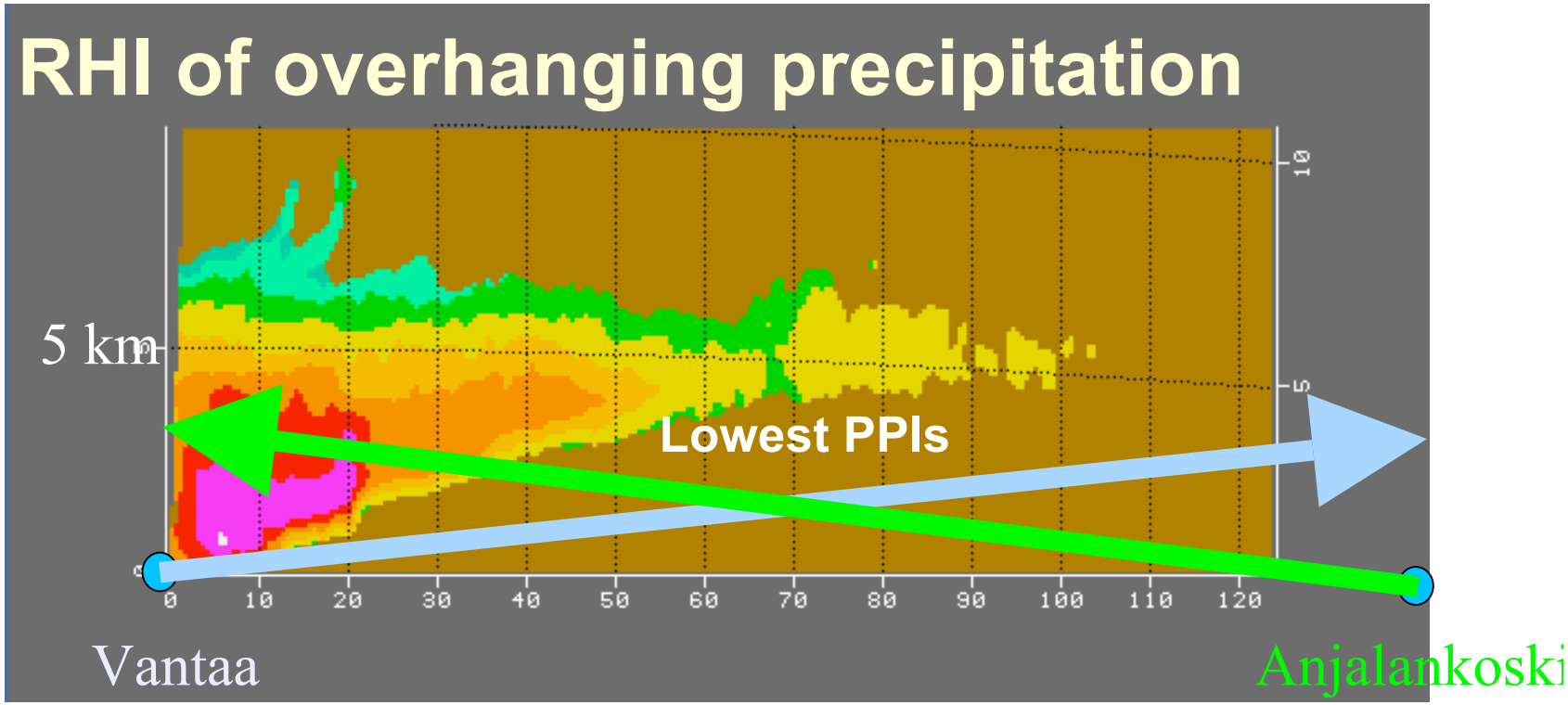
Real time algorithms developed: Probability of detection (POD) as a function of range

Nov 20-31, 2004





Remaining QPE challenges



Finland: 20 % of all precipitation never reaches the ground (based on 200 000 Vertical Profiles of Reflectivity, VPR)

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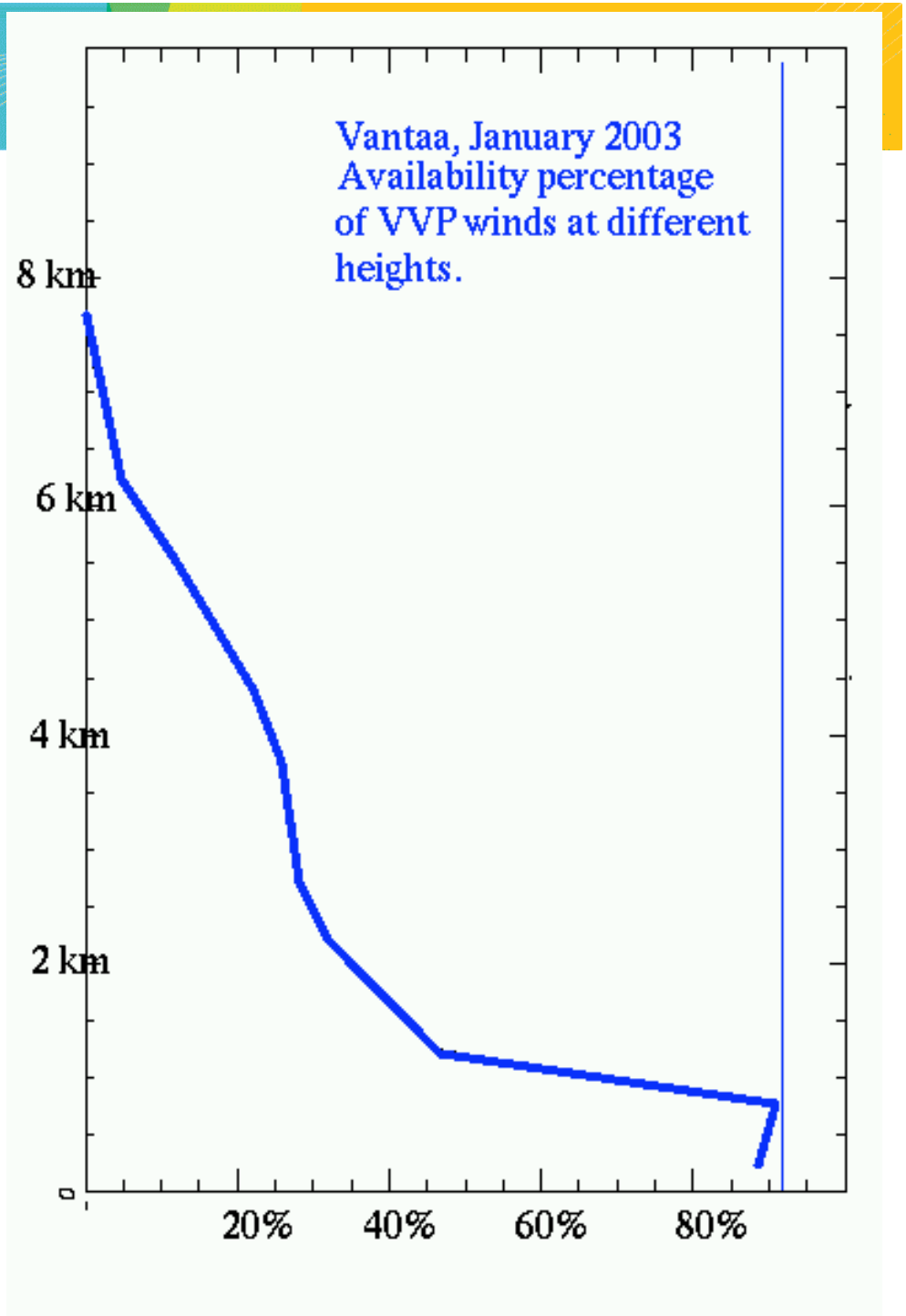
Gauge-radar comparison problem in snowfall: Horizontal drifting of snow particles easily 50-100 km during their fall to ground.

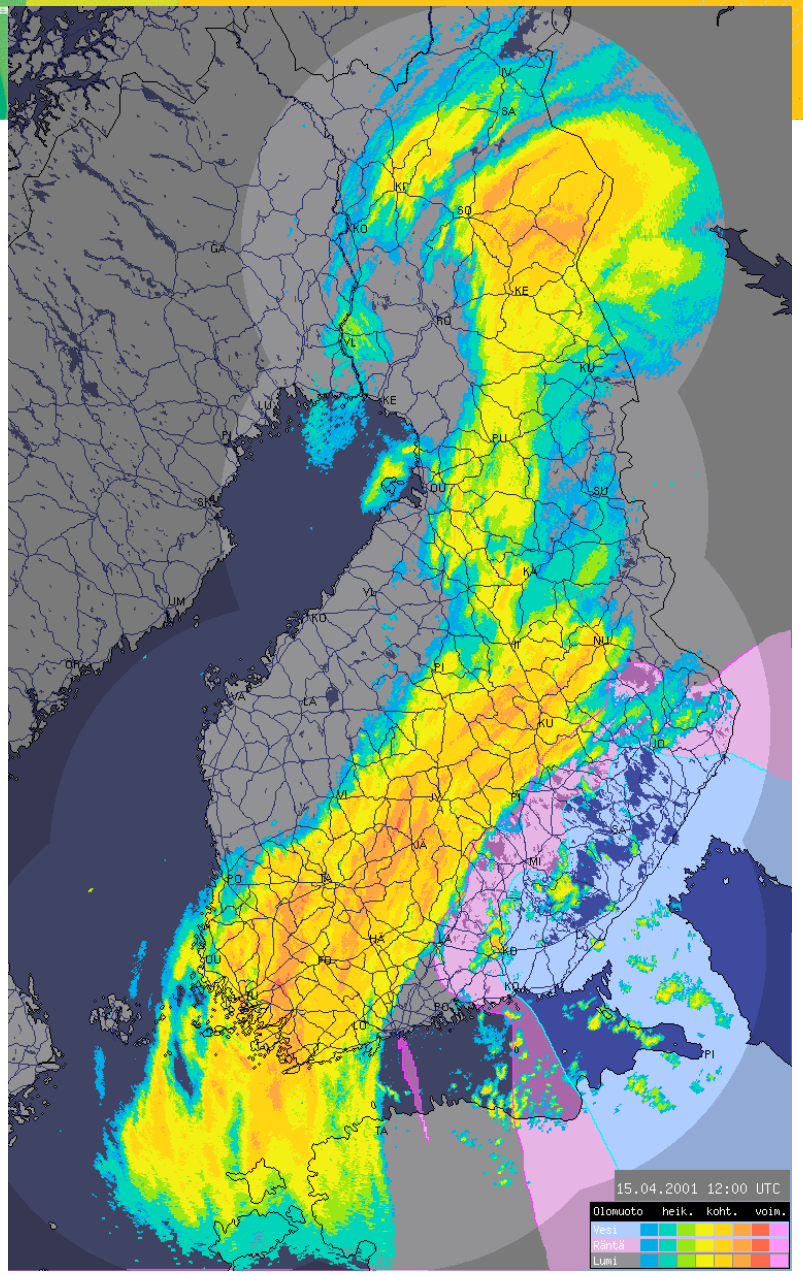
In boundary layer Doppler winds obtainable 90 % of time in winter (ice crystals from the ground ?) with sensitive radars



Better accuracy with optimal SFWE(Z_e)?

- Hydrometeor phase analysis (rain, sleet, snow) based on Kriging-analysis of SYNOP data (T,RH). Resolution 5 min & 1 km (extrapolation).
- Time-space variable R(Z) & SFWE(Z_e) relations.
- Operational since 1999:

  Grey background: snow
  Blue background: rain
  Pink background: mixed



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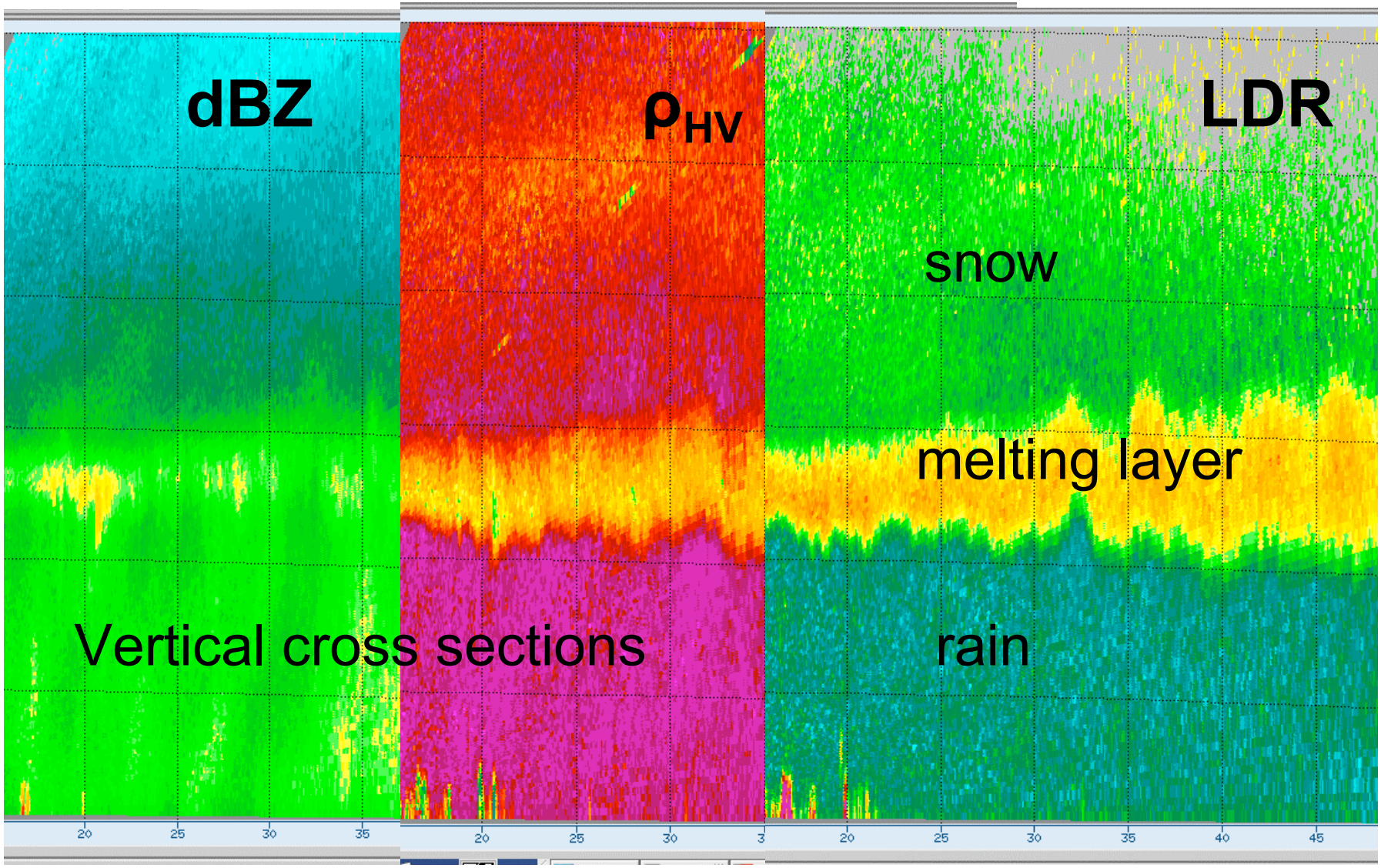
Do optimal SFWE(Z_e) or SFWE(Z_e, DPOL) exist?



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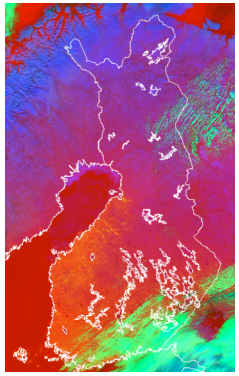
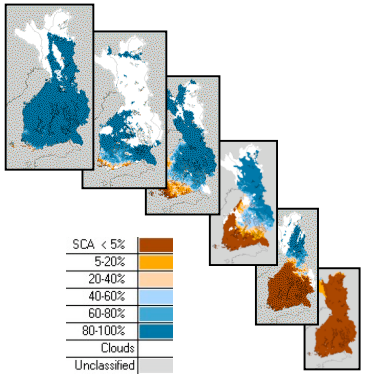
Operational Snow melt monitoring



Reflectance model:
SCA for each basin



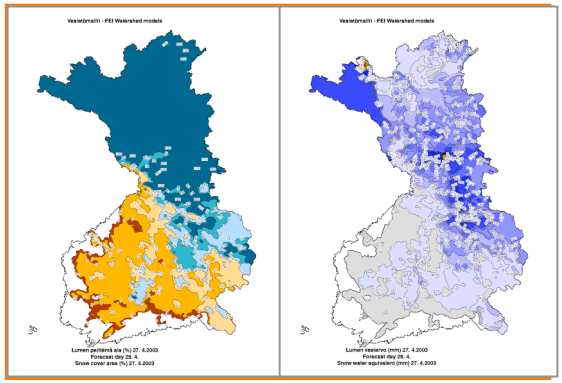
hydrological model

SCA

Model input:
- Precipitation
- Temperature

Snow CoveredArea

Field observations:
- Discharge
- Water level
- SWE



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Development and validation of snow emission models with airborne microwave radiometer data

- Co-operation between FMI, TKK and Environment Canada in the analysis of Finnish and Canadian airborne data
- Further development and validation of HUT Snow Emission Model
  - Snow-covered lake or sea ice
  - Inclusion of depth hoar layer